APPROVAL MEMO

MEMORANDUM

INTERMOUNTAIN POWER SERVICE CORPORATION

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THX — JN

TO: George Cross

CC: Jerry Hintze, James Nelson

FROM: Dennis Killian

DATE: August 27, 2002

SUBJECT: Primary/Secondary Air Heater Replacement

~~ATTACHED~~ ENCLOSED ALSTOM CUT SHEETS SHOULD ALSO BE ATTACHED.

This memo is a recommendation on upgrading the SAH's and suppling cost estimates for the 2003-04 and 2004-05 budgets.

It is recommended that IPSC upgrade the SAH's with the Air Preheater Company's (Alstom) ClearFlow technology starting the March 2004 outage. Cost analysis shows payback in under 2 years with a Benefit-to-Cost Ratio of 12.3.

There is not sufficient justification at this point to recommend PAH replacement. This submission is based on an economic payback of about 4.5 years and a Benefit-to-Cost Ratio of 4.6. However, restoration of the PAH's will continue to be evaluated on a year to year basis.

Total project cost for both Units for replacement of the SAH's is estimated at approximately $3.3 Million.

Contact Bret Kent at ext. 6447 with questions.

Approval: ________________

George W. Cross
IPSC Pres. & COO

DBK/

Attachments: 1)Background
2)S:\ENGINEER\OSENGINEER\1BRET-K\AH\Clearflow.doc
3)S:\ENGINEER\OSENGINEER\1BRET-K\AH\Duplex Upgrade Brochure.doc

IP7_034116

Background

General

The significant advances in air heater technology warrants the evaluation of alternative designs to achieve improved efficiency. A preliminary assessment demonstrated that an upgrade of the Secondary Air Heaters is viable. As a result of this study, the scope of the investigation was expanded to include the Primary Air Heaters. It is the determination of this assessment that the Air Preheater Company's (Alstom) replacement-in-kind and their ClearFlow upgrade are the only practical option currently on the market. Description of these systems is included at the end of the background section.

The following budgetary numbers were used in calculating payback.

- Fuel Cost: $1.52/million BTU
- Power Production Cost: $0.025/KW
- Labor Rate $35.00/hr

The result are as follows, with detail under the corresponding section:

SAH *(Annually per Unit)*	**Replacement In-Kind**	**ClearFlow w/ Duplex Sealing**
Fuel Savings:	$0	$654,116
Fan Savings:	$320,033	$220,666
Total Savings:	**$320,033**	**$874,782**
Installation:	$210,560	$467,600
Materials:	$923,700	$1,153,900
Total Cost:	**$1,134,260**	**$1,621,500**
Pay Back [Yrs]:	3.54	1.85

PAH *(Annually per Unit)*	**Replacement In-Kind**	**ClearFlow w/ Duplex Sealing**	**ClearFlow w/ Duplex Sealing & LRS-2k**
Fuel Savings:	$0	$74,223	$74,223
Fan Savings:	$23,350	$19,758	$23,639
Total Savings:	**$23,350**	**$93,981**	**$97,862**
Installation:	$45,850	$210,560	$210,560
Materials:	$125,000	$207,200	$332,200
Total Cost:	**$170,850**	**$417,760**	**$542,760**
Pay Back [Yrs]:	7.32	4.45	5.55

Primary Air Heaters

Present operating conditions show pressure differential for the PAH's running at an average of 2.70 INWC. This is 54% above design point of 1.75 INWC. Alstom estimates that this is costing IPSC $46,700 annually in PA Fan energy costs.

Labor

- RIK man-hour estimates show that 6 men working 10 hour shifts will complete the change out for 1 PAH in 7.5 shifts.
- ClearFlow and Duplex labor estimates call for 6 men working 12 hour shifts to complete change out for 1 PAH in 32 shifts.
- An Alstom provided Field Service Engineer will cost $700/day

This time table could be compressed by adding more labor and/or by combining common tasks for the 2 Primary Air Heaters in each Unit.

Payback (per Unit)

A. ClearFlow w/ DL7 one layer element

ClearFlow, Duplex Seal, and DL7 Elements

1. Fuel Savings(annual): $93,981
2. Material Cost: $207,200
3. Labor Cost: $210,560
4. Total Cost Per Unit: $417,760

Assuming a project life of 15 years, O&M escalation at 3% and 6.35% cost of money, also assuming operation and maintenance on the new system is $10,000 per year in present value (PV), and assuming we will realize a savings of $93,981 annually (in present value), the following is projected:

Project Life in Years:	15
O&M Rate	3.00%
Cost of Money Rate:	6.35%
Annual O&M Cost (PV):	$10,000
Annual Savings (PV):	$93,981
Capital Cost (PV):	$417,760
Salvage Value (PV):	$0

FV of O&M Cost:	$185,989
PV of Total O&M Cost:	$73,863
Total Cost over Life of Project:	$491,623
PV of Annual Savings Over Life of Project:	$2,246,721

Payback Period in Years:	4.45
Benefit/Cost Ratio:	4.57

B. <u>ClearFlow w/ DL7 one layer element and LRS-2k</u>

LRS02k is an additional seal that eliminates the 3/8" gap.

1. Additional Savings (annual): $3,880
2. System Cost: $125,000

Assuming a project life of 15 years, O&M escalation at 3% and 6.35% cost of money, also assuming operation and maintenance on the LRS-2k system is $2,000 per year in present value (PV), and assuming we will realize a savings of $3,880 annually (in present value), the following is projected:

Project Life in Years:	15
O&M Rate	3.00%
Cost of Money Rate:	6.35%
Annual O&M Cost (PV):	$2,000
Annual Savings (PV):	$3,880
Capital Cost (PV):	$125,000
Salvage Value (PV):	$0

FV of O&M Cost:	$37,198
PV of Total O&M Cost:	$14,773
Total Cost over Life of Project:	$139,773
PV of Annual Savings Over Life of Project:	$92,756

Payback Period in Years:	32.22
Benefit/Cost Ratio:	0.66

Secondary Air Heaters

Data prior to the March 2002 Outage show the SAH pressure differential average was 7.00 INWC (during the 950MW test, differential pressures in Unit 2 peaked at over 10 INWC). This is 126% above their design point of 3.10 INWC. This 3.9 INWC pressure differential could be realized in an equivalent $640,000 annual savings in power consumption on the ID Fans, through in-kind basket replacement and general heater refurbishment.

Labor

- RIK man-hour estimates show that 12 men working 12 hour shifts will complete the change out for 1 SAH in 16 shifts.

- ClearFlow and Duplex labor estimates require 12 men working 12 hour shifts to complete change out for 1 SAH in 37.5 shifts.
- An Alstom provided Field Service Engineer will cost $700/day

This time table could be compressed by adding more labor and/or by combining common tasks for the 2 Secondary Air Heaters in each Unit.

Payback (per Unit)

<u>ClearFlow w/ DL7 two layer element</u>

ClearFlow and DL7 Elements

1. Fuel Savings(annual): $874,782
2. Material cost: $1,153,900
3. Labor Cost: $467,600
4. Total Cost per Unit: $1,621,500

Assuming a project life of 15 years, O&M escalation at 3% and 6.35% cost of money, also assuming operation and maintenance on the new system is $10,000 per year in present value (PV), and assuming we will realize a savings of $874,782 annually (in present value), the following is projected:

Project Life in Years:	15
O&M Rate	3.00%
Cost of Money Rate:	6.35%
Annual O&M Cost (PV):	$10,000
Annual Savings (PV):	$874,782
Capital Cost (PV):	$1,621,500
Salvage Value (PV):	$0

FV of O&M Cost:	$185,989
PV of Total O&M Cost:	$73,863
Total Cost over Life of Project:	$1,695,363
PV of Annual Savings Over Life of Project:	$20,912,646
Payback Period in Years:	1.85
Benefit/Cost Ratio:	12.34

Definition of Options Presented

Replacement In-kind (RIK)
In-kind Replacement would consist of replacement of DL elements and general air heater refurbishment. It would restore the air heaters to design specifications. Lost performance would be regained, but no additional capability provided.

ClearFlow
There are several advantages to the Alstom ClearFlow upgrade.

First, the ClearFlow upgrade will eliminate the support grating between the soot blower and the element sheets used to support each element. Instead, stay plates installed between the diaphragms will carry the element baskets. Presently, the area behind the support grating bars is not easily cleaned, as a result of obstructions to the cleaning media.

Secondly, going to the two layer element design isolates the fouling zone to the cold end layer. Since this area is where the soot blowing energy is maximized, fouling is conversely minimized. When the soot blowing media leaves the element layer, the media energy dissipates to the sides and energy is lost rapidly. This occurs on each layer, so consequently in a three layer design the intermediate layer receives less cleaning energy and the hot end layer significantly less. In most cases, a ClearFlow up-grade requires less soot blowing frequency and less soot blowing pressures thereby extending the life of the heating element.

Lastly, with reduced obstruction and better cleanout, the fan power requirements are cut. This not only saves in power costs, but in the mechanical life of the fan.

DL7
A ClearFlow upgrade could use several different types of heating elements. Since each element profile is designed for a particular fuel or fouling problem, the optimized selection (for the proposed replacement) are the DL7 elements. The DL7 are a loose pack element, same as the existing DL profile, but with a higher thermal performance, allowing a drop from 3 layers to 2.

Another option available with the ClearFlow up-grade is not only turning over (or flipping) the element baskets, as with the present heaters, but because both the hot end and cold end layers are the same depth (41"), the hot and cold end layers can be switched as the elements wear. This allows for more even wear on the hot and cold ends of each layer.

Duplex Sealing

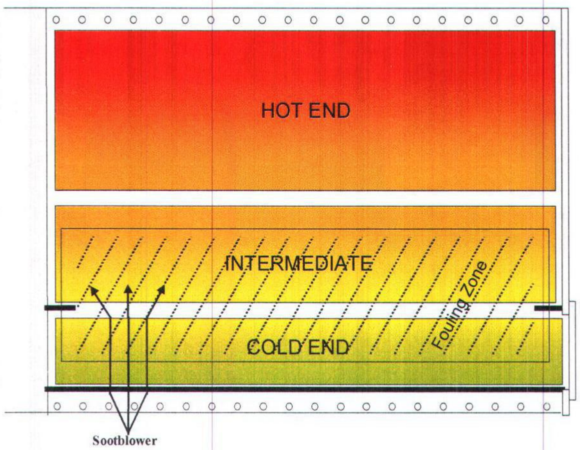
With the existing air heater design, one radial and one axial seal (attach to the diaphragm plate) are constantly in contact with a stationary sealing surface. In practice, this single seal provides a leakage reduction that is influenced by the amount of pressure differential that causes the leakage. If two seals are in contact with the sealing surface at the same time, the second seal surface is influenced by a reduced pressure differential that results from the pressure drop across the first seal. Duplex sealing incorporates two seals at each stationary sealing surface to effectively reduce pressure differential by 50% and direct leakage by 30%. This is accomplished by modifying the rotor to double the number of diaphragms and seals. See the attached brochure.

LRS-2K

The PAH leak as a result of excessive seal war during startup. Because hot gas is flowing through the PAH when the PA fan in not operating, the rotor takes on an extreme upward thermal deformation that would not normally be experienced when air is flowing to dissipate heat from the gas flow. This upward expansion causes the outboard ends of the hot radial and cold ends of the axial seal to "scrub out", resulting in excessive seal gaps when normal operation is obtained. At present approximate 3/8" gaps exist in the PAH's at the outboard hot radial locations in a cold condition when this gap should be 0". With the LRS-2K the seal plate is positioned away from the seals during start up, once the heater reaches normal operating conditions, the sealing plate would reposition to close the gap and minimize leakage.

Clearflow™ Rotor Design

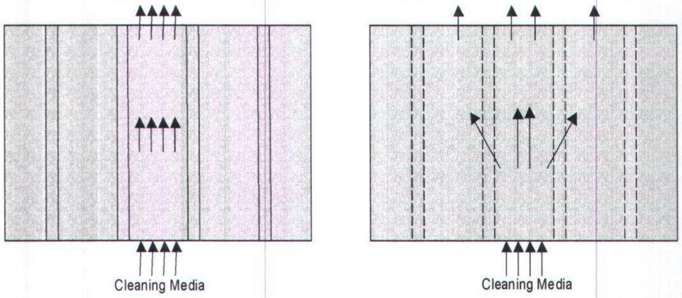
Today's power generation requirements dictate that essentially all fossil fired units be capable of cyclic and low-load operation. This reduced load operation lowers flue gas temperature, resulting in increased fouling of the combustion air preheater. Controlling air preheater fouling is key to maintaining unit availability, reliability and heat rate.



Conventional designs allow fouling to migrate into the intermediate and possibly hot end element layers.

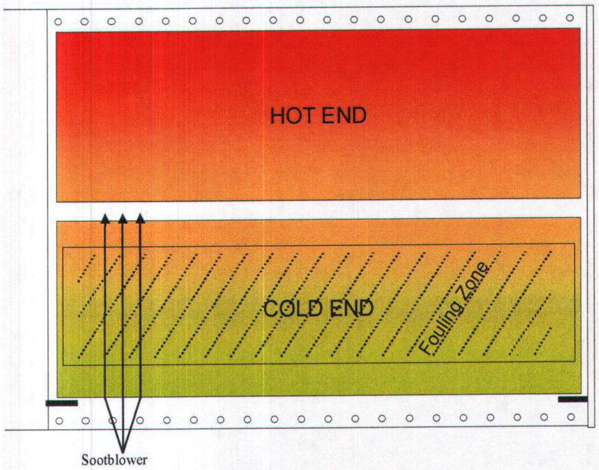
Conventional air preheater designs use a shallow layer of closed channel heat transfer surface in the cold end, intended to contain the fouling zone and facilitate cleaning. While this is effective at full load operation, reduced temperatures associated with low load operation allow this fouling zone to expand into the adjacent, open channel element layers.

Closed Channel Surface **Open Channel Surface**



Closed channel heat transfer surfaces demonstrate improved cleanability by preventing diffusion of cleaning media.

Closed channel heat transfer surfaces demonstrate superior cleaning characteristics as the result of their continuous axial contact with adjacent element sheets. This prevents diffusion of the cleaning media, significantly improving cleaning effectiveness. Allowances for today's operation can include a depth extension of this closed channel layer to contain an expanded fouling zone.



Clearflow™ designs contain fouling potential in a single extended depth cold end layer of closed channel surface.

Further improvements in cleanability can be achieved through utilization of a basket support system, which minimizes obstructions to the cleaning media. Retrofitting this element configuration to an existing air preheater requires relatively minor modifications to the basket support arrangement.

This Clearflow™ design arrangement addresses many of the root causes of air preheater fouling, thereby minimizing the duty on air preheater cleaning equipment. By eliminating aggressive cleaning practices, meaningful extensions in heat transfer surface life are often available. This extension in life further enhances the benefit of controlling fouling in the Ljungstrom® Air Preheater.

CLEARFLOW™ DESIGN

- Reduces fan power requirements
- Maintains unit availability
- Reduces washing requirements
- Extends element life

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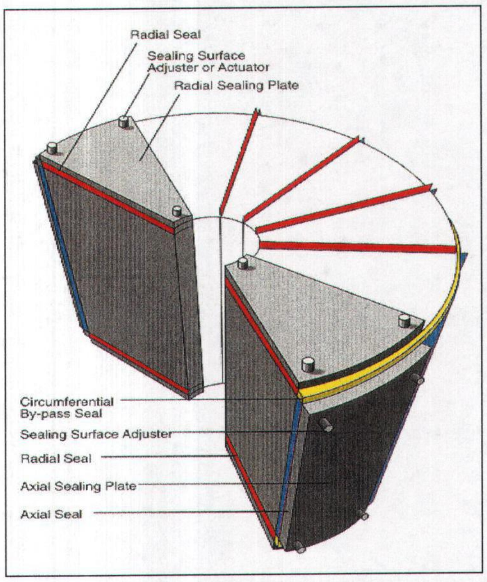
Ljungstr`m Air Preheater Duplex☺
Design Upgrade for Passive Leakage Reduction

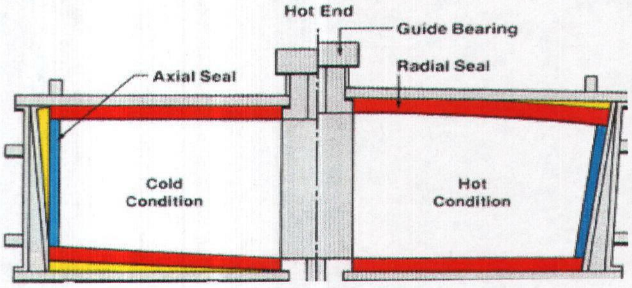
Sealing System

- Leaf-type proximity seals attached to the radial and axial length of each rotor diaphragm
- Two radial sealing plates (sector plates) are located at each end of the rotor
- Two axial sealing plates are diametrically opposite each other in line with the sector plates
- Circumferential by-pass seals to prevent air and gas bypassing the rotor



Leakage Problem

- All seals can be set properly in cold condition except hot end radial seals.
- Hot end radial gap causes large amount of leakage
- High leakage rates can reduce generating capacity



Leakage Solution - Duplex☺ Sealing

- Incorporates 2 proximity seals at each stationary sealing surface
- Reduces effective pressure differential by 50%
- Reduces direct leakage by 30%
- Reduces erosion, rate of leakage degradation
- Regains lost generating capacity